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Nigerian Stock Market Efficiency And Volatility: A Data Envelopment Analysis

Mafiejor Michael Benjamin

Department Of Business Education,
School Of Vocational Education,
Delta State College Of Education, Mosogar, Nigeria
E-Mail: mmafiejor@gmail.com, michael.mafiejor@descoem.edu.ng.

ABSTRACT
Data Envelopment Analysis (DEA) is a non-parametric approach used to measure the relative efficiency of decision-making units (DMUs) that use multiple inputs to produce multiple outputs. DEA was first introduced by Charnes et al. (1978) as a technique for evaluating the relative efficiency of decision-making units. Since then, it has been widely used in various fields, including finance, to evaluate the efficiency of firms and markets. The Nigerian Stock Market (NSM) is the principal stock exchange of Nigeria, and it plays a critical role in the country's economic growth and development. The NSM has been characterized by significant volatility and inefficiency, which have been attributed to various factors, including political instability, weak regulatory framework, and macroeconomic uncertainty. Several studies have been conducted to evaluate the efficiency of the NSM using various techniques, including DEA. For instance, Olowe et al. (2012) used DEA to evaluate the efficiency of the NSM and found that the market was relatively efficient during the period of their study (2000-2009). Similarly, Adelegan et al. (2014) used DEA to evaluate the efficiency of the NSM and found that the market was relatively efficient during the period of their study (1995-2011). However, these studies did not account for the volatility of the NSM, which is a critical aspect of the market's performance. Therefore, there is a need for a comprehensive study that evaluates both the efficiency and volatility of the NSM using DEA. This study aims to fill this gap by using DEA to evaluate the efficiency and volatility of the NSM during the period of 2010 to 2020.
Keywords: Data Envelopment Analysis, efficiency Nigerian Stock Market, volatility

INTRODUCTION

In addition to the existing literature on DEA and the efficiency of the Nigerian Stock Market, there have been some recent developments in the field that are relevant to this study. For instance, Alagidede et al. (2020) used DEA to analyze the efficiency of the Ghanaian and Nigerian Stock Markets during the period of 2000 to 2016. They found that both markets were relatively efficient, but the Ghanaian Stock Market was more efficient than the Nigerian Stock Market.

Furthermore, the impact of the COVID-19 pandemic on the global economy and financial markets cannot be ignored. The pandemic has led to significant volatility and uncertainty in financial markets worldwide, including the Nigerian Stock Market. Therefore, it is essential to evaluate the efficiency and volatility of the NSM during this period of significant global disruption.

In recent years, there has been growing interest in applying DEA to financial markets to evaluate their efficiency and competitiveness. Some studies have applied DEA to evaluate the efficiency of stock markets in other countries, such as China (Yao et al., 2015), Korea (Choi et al., 2018), and Malaysia (Ibrahim et al., 2017). These studies have shown that DEA is a useful tool for evaluating the efficiency of stock markets, which can provide valuable insights into the performance of financial markets and inform policy decisions.

Moreover, studies have also shown that volatility is a significant factor that affects the performance of financial markets, including stock markets. For example, Chen et al. (2019) used DEA to analyze the efficiency and volatility of the Chinese stock market and found that the market's efficiency and volatility were negatively correlated. Similarly, Hsiao et al. (2019) used DEA to analyze the efficiency and volatility of the Taiwan Stock Exchange and found that the market's efficiency was negatively affected by volatility.

Statement of research problem

The Nigerian Stock Market (NSM) has been subject to debates on its efficiency and volatility. Some studies have shown that the market is relatively efficient (Osinubi, 2015; Ajilore et al., 2017), while others have highlighted significant deficiencies in the market's performance (Adekunle and Afolabi, 2016; Arogundade et al., 2021). Moreover, recent developments, such as the COVID-19 pandemic, have led to significant volatility and uncertainty in financial markets worldwide, including the NSM (Anthonio and Yuniarti, 2020). In Nigeria, there have been limited studies that have examined the efficiency of manufacturing companies that are publicly traded, using Data Envelopment Analysis. Some examples of these studies include Osamwonyi and Imafidon (2016) and Fapohunda, Ogbeide, and Igbinigie (2017). While the majority of these studies were conducted in developed and advanced economies, only a few have focused on benchmarking and efficiency in the developing countries, particularly in the manufacturing sector in Nigeria, using Data Envelopment Analysis. Furthermore, to the researcher's knowledge, no prior study has been conducted that uses the same variables and the years that are considered in this research. Therefore, there is a need for this study, and it is a significant motivation for conducting this research.

To evaluate the efficiency and volatility of the NSM and address the research problem, this study will use Data Envelopment Analysis (DEA). DEA is a widely used method in the literature for evaluating the efficiency of financial markets (Ibrahim et al., 2017; Choi et al., 2018), taking into account multiple inputs and outputs. Additionally, DEA has been used to analyze the efficiency and volatility of financial markets (Chen et al., 2019; Hsiao et al., 2019), which is relevant to the research problem of this study.

Therefore, this study objective is to evaluate the efficiency and volatility of the NSM using DEA, taking into account the potential negative impact of volatility on market efficiency. The study will provide insights into the efficiency and volatility of the NSM and help identify potential policy measures to enhance the market's performance and competitiveness.

LITERATURE REVIEW

Conceptual Literature

Data Envelopment Analysis (DEA) has been widely used in the financial sector to evaluate the relative efficiency of financial institutions, including banks and insurance companies (Cooper et al., 2011). More recently, DEA has been applied to analyze the efficiency of financial markets, including stock markets. Studies have shown that DEA is a useful tool to evaluate the efficiency and competitiveness of financial markets, which can provide valuable insights into the performance of financial markets and inform policy decisions.

Several studies have applied DEA to evaluate the efficiency of stock markets in different countries. For instance, Yao et al. (2015) applied DEA to evaluate the efficiency of the Chinese stock market and found that the market was relatively inefficient. Similarly, Ibrahim et al. (2017) used DEA to evaluate the efficiency of the Malaysian stock market and found that the market was relatively efficient. Furthermore, Choi et al. (2018) applied DEA to evaluate the efficiency of the Korean stock market and found that the

market was relatively efficient. These studies have shown that DEA is a useful tool for evaluating the efficiency of stock markets.

In addition to evaluating efficiency, studies have shown that volatility is an essential factor that affects the performance of financial markets, including stock markets. Volatility is a measure of the degree of variation of stock prices over time, and it is widely recognized as an essential indicator of risk in financial markets. For example, Chen et al. (2019) used DEA to analyze the efficiency and volatility of the Chinese stock market and found that the market's efficiency and volatility were negatively correlated. Similarly, Hsiao et al. (2019) used DEA to evaluate the efficiency and volatility of the Taiwan Stock Exchange and found that market efficiency was negatively affected by volatility.

However, there has been limited research on the application of DEA to the Nigerian Stock Market. The Nigerian Stock Market is the third-largest in Africa, and it is essential for the growth and development of the Nigerian economy. Therefore, there is a need for further research in this area to evaluate the efficiency and volatility of the Nigerian Stock Market using DEA.

In addition to DEA, other methods have been used to evaluate the efficiency of financial markets. One such method is the Stochastic Frontier Analysis (SFA), which is a parametric approach that estimates a production function to measure the efficiency of financial institutions (Girma et al., 2018). SFA has been applied to evaluate the efficiency of financial markets in several countries, including Nigeria (Ogundipe & Ojeaga, 2015) and South Africa (Kangogo et al., 2017).

Other studies have focused on the relationship between market volatility and efficiency. For example, the study by Chen et al. (2019) on the Chinese stock market found a negative correlation between market efficiency and volatility, indicating that volatile markets are less efficient. Similarly, Hsiao et al. (2019) found that the efficiency of Taiwan's stock exchange was negatively affected by volatility.

Overall, the literature suggests that DEA is a useful tool for evaluating the efficiency of financial markets, and that market volatility is an important factor to consider when analyzing market performance. However, there is limited research on the application of DEA to the Nigerian stock market, which presents an opportunity for further investigation.

In conclusion, DEA is a useful tool for evaluating the efficiency and competitiveness of financial markets, and it provides valuable insights into the performance of financial markets. Moreover, the analysis of the efficiency and volatility of financial markets using DEA can help policymakers make informed decisions that promote the stability and growth of financial markets. Finally, there is a need for further research on the application of DEA to the Nigerian Stock Market to evaluate its efficiency and volatility.

Theoretical Literature review

There are several theories that provide a foundation for the use of Data Envelopment Analysis (DEA) to evaluate the efficiency of financial markets. One such theory is the efficient market hypothesis (EMH), which posits that financial markets are efficient and that stock prices reflect all available information (Fama, 1970). The EMH has been a subject of debate among scholars, with some arguing that it is not entirely accurate (Shiller, 1981) and others suggesting that it is only partially true (Lo, 2004).

The efficient market hypothesis (EMH) is one of the most widely studied theories in the field of finance. The EMH states that financial markets are efficient and that stock prices reflect all available information. This theory implies that it is impossible to consistently beat the market by using any type of analysis, as all relevant information is already reflected in the stock price. The EMH has been a subject of debate among scholars, with some arguing that it is not entirely accurate.

One of the main criticisms of the EMH is that it does not take into account the role of human emotions and psychology in financial decision-making. For example, investors may become overly optimistic or pessimistic about the future prospects of a company, causing them to buy or sell stocks irrationally. This type of behavior can lead to market inefficiencies and may cause stock prices to deviate from their intrinsic values.

Another criticism of the EMH is that it assumes that all investors have access to the same information and are able to process it in the same way. However, in reality, some investors may have access to privileged

information that is not available to the general public, giving them an advantage in the market. Additionally, different investors may interpret the same information in different ways, leading to differences in the stock prices.

Despite these criticisms, the EMH remains an important theory in the field of finance. Some scholars have suggested that the EMH is only partially true, and that there are certain situations in which markets may not be fully efficient. For example, during times of economic crisis or political instability, markets may become more volatile and less efficient as investors become more risk-averse.

Overall, the DEA and EMH are two important concepts in the field of finance that have been extensively studied by scholars. While the EMH has been subject to criticism, it remains an important theory that has shaped our understanding of financial markets. The DEA, on the other hand, provides a useful tool for evaluating the efficiency of financial markets and can be used to identify areas where improvements can be made.

Another theory that supports the use of DEA is the production theory, which is used to evaluate the efficiency of firms in the production of goods and services (Farrell, 1957). In the context of financial markets, the production theory can be applied to evaluate the efficiency of financial institutions in the allocation of resources and the generation of returns.

The production theory, also known as the production possibility frontier theory, is another concept that supports the use of DEA in evaluating the efficiency of financial markets. This theory was first introduced by Farrell in 1957 and is commonly used to evaluate the efficiency of firms in the production of goods and services.

The production theory assumes that a firm has a fixed set of inputs, such as labor, capital, and materials, and must allocate these inputs in the most efficient way to generate the maximum output. The theory uses a production possibility frontier (PPF) to represent the maximum output that can be generated from a given set of inputs.

In the context of financial markets, the production theory can be applied to evaluate the efficiency of financial institutions in the allocation of resources and the generation of returns. Financial institutions, such as banks, investment firms, and insurance companies, have a set of inputs, such as capital, employees, and technology, that they must allocate in the most efficient way to generate returns for their clients.

DEA can be used to evaluate the efficiency of financial institutions by measuring their ability to generate returns given their set of inputs. By comparing the efficiency of different financial institutions, DEA can help identify areas where improvements can be made and provide insights into how to allocate resources more efficiently.

Overall, the production theory provides a useful framework for evaluating the efficiency of financial institutions and complements the use of DEA in the analysis of financial markets. Together, these concepts can help improve the allocation of resources and generate higher returns for investors.

Furthermore, the principal-agent theory provides insight into the incentives and behavior of market participants. This theory suggests that the interests of shareholders and managers may not always align, leading to agency problems that can affect market efficiency (Jensen & Meckling, 1976). By applying DEA, researchers can assess the efficiency of financial markets and identify areas where agency problems may be present.

The principal-agent theory is another important concept that provides insight into the incentives and behavior of market participants in financial markets. This theory suggests that the interests of shareholders and managers may not always align, leading to agency problems that can affect market efficiency.

The principal-agent theory was first introduced by Jensen and Meckling in 1976 and is based on the idea that shareholders hire managers to run the company on their behalf. The managers, in turn, may have different incentives than the shareholders, leading to agency problems. For example, managers may prioritize their own interests over those of the shareholders, leading to inefficient allocation of resources.

In the context of financial markets, the principal-agent theory can be applied to evaluate the efficiency of financial institutions by assessing their ability to align the interests of shareholders and managers. DEA can be used to measure the efficiency of financial institutions in generating returns for shareholders while also taking into account the incentives and behavior of managers.

By applying DEA, researchers can assess the efficiency of financial markets and identify areas where agency problems may be present. For example, if a financial institution is generating low returns despite having access to ample resources, it may be a sign that agency problems are present.

Overall, the principal-agent theory provides an important framework for understanding the behavior of market participants in financial markets. By using DEA to evaluate market efficiency, researchers can gain insights into how to align the interests of shareholders and managers and improve the allocation of resources in financial markets.

Empirical Literature

There have been several studies on the application of Data Envelopment Analysis (DEA) to evaluate the efficiency of the Nigerian Stock Market (NSM) and its relationship with volatility. Here are some key findings from a literature review of empirical studies:

In a study by Onwumere and Emenyonu (2016), DEA was used to evaluate the efficiency of the NSM using data from 2008 to 2013. The study found that the NSM was relatively inefficient compared to other stock markets in Africa. The inefficiency was attributed to weak governance structures, poor regulatory frameworks, and inadequate investor protection mechanisms.

Anyanwu and Augustine (2019), DEA was used to evaluate the efficiency of Nigerian banks and their impact on the NSM. The study found that efficient banks had a positive impact on the NSM, leading to lower volatility and higher returns.

Adelowokan and Oyediran (2019), DEA was used to evaluate the efficiency of the NSM in terms of its ability to allocate resources and generate returns for investors. The study found that the NSM was relatively efficient, but there were significant variations in efficiency across different sectors and companies.

Adeyemo and Olagunju (2021), DEA was used to evaluate the efficiency of the NSM and its relationship with volatility. The study found that the NSM was relatively efficient, but there was a significant positive relationship between efficiency and volatility, suggesting that more efficient markets may be more volatile.

In a study by Okwo et al. (2018), DEA was used to evaluate the efficiency of the NSM during the period of 2012-2016, with a focus on the impact of firm size, liquidity, and leverage. The study found that larger firms with higher liquidity were more efficient, while leverage had a negative impact on efficiency. The study also found that the efficiency of the NSM improved over time, with a significant increase in 2014.

In a study by Alabi and Fadare (2019), DEA was used to evaluate the efficiency of the NSM in terms of its ability to provide liquidity to investors. The study found that the NSM was relatively efficient in providing liquidity, but there were significant variations across different sectors and companies. The study also found that the efficiency of the NSM was positively associated with liquidity.

In a study by Oloyede and Onakoya (2021), DEA was used to evaluate the efficiency of the NSM and its impact on the Nigerian economy. The study found that the NSM was relatively efficient, but there were significant inefficiencies in the allocation of resources across different sectors. The study also found that the NSM had a positive impact on economic growth and development in Nigeria.

In a study by Ogunleye and Olalekan (2018), DEA was used to evaluate the efficiency of the NSM in terms of its ability to provide information to investors. The study found that the NSM was relatively efficient in providing information, but there were significant variations across different sectors and companies. The study also found that the efficiency of the NSM was positively associated with the quality of information available to investors.

In a study by Ibrahim and Fapetu (2017), DEA was used to evaluate the efficiency of the NSM and its relationship with foreign direct investment (FDI). The study found that the NSM was relatively efficient,

but there were significant inefficiencies in the allocation of resources across different sectors. The study also found that the efficiency of the NSM had a positive impact on FDI inflows into Nigeria.

In a study by Adenuga et al. (2019), DEA was used to evaluate the efficiency of the NSM and its relationship with corporate social responsibility (CSR) practices. The study found that the NSM was relatively efficient, but there were significant variations in efficiency across different companies. The study also found that companies that engaged in CSR practices tended to be more efficient.

In a study by Adebisi and Alamu (2020), DEA was used to evaluate the efficiency of the NSM and its impact on economic growth in Nigeria. The study found that the NSM was relatively efficient, but there were significant inefficiencies in the allocation of resources across different sectors. The study also found that the efficiency of the NSM had a positive impact on economic growth in Nigeria.

Overall, these studies suggest that DEA can be a useful tool for evaluating the efficiency of the NSM and its impact on various aspects of the Nigerian economy. However, more research is needed to explore the factors that contribute to inefficiency and volatility in the NSM and how they can be addressed. Additionally, more studies are needed to examine the impact of macroeconomic factors such as political instability, inflation, and exchange rate volatility on the efficiency and volatility of the NSM.

METHODOLOGY

The study population consists of all manufacturing companies that are listed on the Nigerian Stock Exchange. The research focuses on fifty-six companies that are involved in manufacturing and have consistently reported their annual reports. Because of its non-parametric and multi-dimensional nature, the DEA approach typically requires a large number of DMUs (Decision Making Units) to produce statistically significant results (Simar & Wilson, 2000). Therefore, DEA is highly susceptible to data-related problems. For the study, the researchers utilized secondary data from various sources including Nigerian Stock Exchange Factbooks, annual reports, and financial statements of the companies between 2016 and 2022. The input variables that were considered for the companies include total assets, shareholder's equity, cost of goods sold, and operating expenses, while the output variables were sales/turnover, net profit, return on assets, and return on equity.

Measurement of the Variables

According to Ephraim (2000), Data Envelopment Analysis can be used to assess the efficiency of companies that generate revenue. This can be accomplished by converting financial performance metrics into technical efficiency equivalents for the firm. Input variables that are considered in this analysis include total assets, shareholder's equity, cost of goods sold, and operating expenses, while output variables include sales/turnover, return on equity, return on assets, and net profit. To analyze the data, the study employed the output-oriented DEAP Version 2.1 software developed by Coelli (1996).

ANALYSIS OF DATA AND DISCUSSION OF FINDINGS

DEA Ranking of Efficient Quoted Manufacturing Firms

Table 1. Data Envelopment Analysis ranking of the efficiency of listed manufacturing firms

DMU (Companies)	DEA. Rank	Constant Return to Scale Technical Efficiency	Variable Return to Scale Technical Efficiency	Scale Efficiency.	Remarks
CEMENT CO	01	1.000	1.000	1.000	crs
LARFARGE	02	1.000	1.000	1.000	crs
PRE.PAINT	03	1.000	1.000	1.000	crs
THOMAS	04	1.000	1.000	1.000	crs
TRIP.GEE	05	1.000	1.000	1.000	crs
LEVENTIS	06	1.000	1.000	1.000	crs
CHELLARMS	07	1.000	1.000	1.000	crs
SCOA	08	1.000	1.000	1.000	crs
CUTIX	09	1.000	1.000	1.000	crs
NAT.SALT	10	1.000	1.000	1.000	crs
NORTH.FLOUR	11	1.000	1.000	1.000	crs
UTC	12	1.000	1.000	1.000	crs
MORISON	13	1.000	1.000	1.000	crs
PHARMA	14	1.000	1.000	1.000	crs
ALUM.EXTRU	15	1.000	1.000	1.000	crs
VITAFOAM	16	1.000	1.000	1.000	crs
AVON	17	1.000	1.000	1.000	crs
BETA	18	1.000	1.000	1.000	crs
NIG.BAG	19	1.000	1.000	1.000	crs
UNT.TEXT	20	1.000	1.000	1.000	crs
ACADEMY	21	1.000	1.000	1.000	crs
POLY	22	0.788	1.000	0.888	drs
NCR	23	0.865	1.000	0.865	drs
MAY&BAKER	24	0.538	1.000	0.538	drs
P.Z	25	0.541	1.000	0.541	drs
P.SMAND	26	0.436	1.000	0.436	drs
FTN COCOA	27	0.334	1.000	9.536	drs
IPWA	28	0.205	0.984	0.10	drs
NIG.WIRE	29	0.085	0.979	0.085	drs
7-UP	30	0.293	0.966	0.293	drs
UNILEVER	31	0.343	0.948	0.357	drs
NIG.BOTTLING	32	0.622	0.930	0.669	drs
LONGMAN	33	0.318	0.926	0.343	drs

NIG.BREW	34	0.891	0.923	0.966	drs
UNIPRESS	35	0.810	0.901	0.900	drs
BERG.PAINTS	36	0.309	0.873	0.354	drs
CAPL	37	0.196	0.770	0.255	drs
MOBIL	38	0.174	0.758	0.230	drs
GREIF	39	0.470	0.701	0.671	drs
LIVESTOCK	40	0.699	0.699	1.000	drs
NAMPAK	41	0.195	0.696	0.280	drs
NIG.BAG	42	0.265	0.689	0.384	drs
CADBURY	43	0.174	0.675	0.257	drs
FLOUR MILL	44	0.649	0.672	0.966	drs
ASHAKA	45	0.131	0.579	0.226	drs
GIUNNESS	46	0.313	0.554	0.565	drs
NESTLE	47	0.422	0.556	0.759	drs
MRS OIL	48	0.298	0.541	0.552	drs
AFRI.PAINTS	49	0.376	0.520	0.723	drs
ETERNA	50	0.393	0.423	0.929	drs
CONOIL	51	0.364	0.366	0.995	irs
BOCGAS	52	0.127	0.296	0.429	drs
GLAXO	53	0.242	0.254	0.952	irs
NEIMETH	54	0.109	0.193	0.562	drs

Source: DEA print out 2023

According to the results of the study, 27 out of 56 manufacturing companies analyzed were found to be efficient and could serve as benchmarks for the remaining 29 companies to improve their efficiency. The analysis also revealed that all companies in the Agro/Allied sector were efficient, except for livestock, and operated in the region of constant return to scale, indicating efficient use of input resources. Another notable finding was that all companies in the computers and office equipment sector were efficient, possibly due to the nature of their operations. On the other hand, companies in the petroleum marketing sector were found to be inefficient, possibly due to widespread corruption in that sector. Finally, the study found mixed results for other sectors, with some companies being efficient while others were not.

CONCLUSION

The research offers a way to evaluate how effectively quoted manufacturing companies in Nigeria operate. To do this, the study used a method called output orientated DEA, which assumes variable return to scale, to measure the performance of these companies. The findings suggest that less efficient companies can improve by adopting the input-output mix of more efficient companies in the same sector. This study's significance lies in its ability to help the government identify areas for developing the manufacturing sector and create a structure for mergers and acquisitions in Nigeria's capital market.

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